Middle Permian brachiopods from the Oguradani Formation, Ise district, Hida Gaien Belt, Central Japan

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Abstract

A Middle Permian (Bolorian-Kubergandian) brachiopod fauna from the lower Oguradani Formation of Oguradani, Ise district, Hida Gaien Belt, Central Japan is described. The brachiopod fauna consists of *Derbyia* cf. *buchi, Meekella* sp., *Transennatia gratiosa, Leptodus nobilis, Stenoscisma margaritovi* and *Hustedia* cf. *grandicosta*. The Oguradani fauna can be correlated with the brachiopod faunas of the lower Moribu Formation of the Moribu district, Hida Gaien Belt, Central Japan; the lower Kanokura Formation of the Southern Kitakami Mountains, Northeast Japan; the Chandalaz Formation of South Primorye, Eastern Russia; and the Miaoling Formation of Yanji, Jilin Province, Northeast China.

Key words: Brachiopods, Middle Permian, Oguradani Formation, Oguradani, Ise district, Hida Gaien Belt, Central Japan

Introduction

The Permian brachiopods described below were collected by the second author (T.M.) from dark-grey argillaceous impure limestone of the lower Oguradani Formation, cropping out at the upper stream of Oguradani, Nojiri in the Ise district, about 80 km south of Kanazawa, Hida Gaien Belt, Central Japan (Fig. 1).

The Oguradani Formation was named by Ozaki *et al.* (1954), and described in detail by Fujimoto *et al.* (1962) and Yamada (1966, 1967). Hayasaka and Matsuo (1951) reported the occurrence of Permian brachiopods, cephalopods, gastropods and bryozoans from the same locality of Oguradani, and they correlated the fauna with that of the lower Kanokura Formation of the Southern Kitakami Mountains, Northeast Japan. But the fossils remained undescribed except for a nautiloid, which was described afterwards by Hayasaka and Ozaki (1955) as *Foordiceras wynneiforme* Hayasaka and Ozaki. From the same locality and horizon Akagi (1958) described a sponge *Amblysiphonella*

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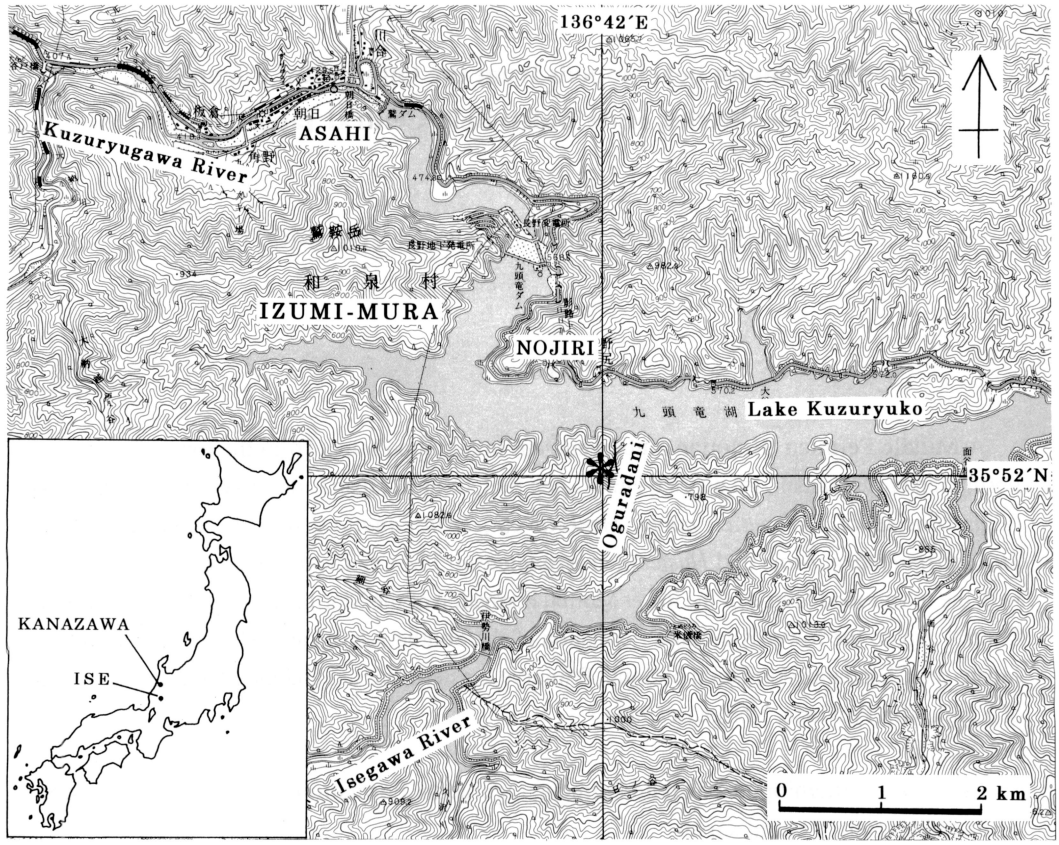

Fig. 1. Map showing the fossil locality (asterisk). Using the topographical map of "Arashimadake" scale 1:50,000 published by Geographical Survey Institution of Japan.

chinense Hayasaka. In addition Yamada (1966, 1967) listed a fusulinacean *Monodiexodina* sp. from limestone of the Oguradani Formation, although the exact locality and horizon were not clear.

In this paper the brachiopod fauna of Oguradani is described, and the correlations with other areas in Japan, Eastern Russia and Northeast China are discussed. The first author (J.T.) is responsible for the systematic descriptions and correlations of the fauna, and the second author is responsible for the field geology and collecting the specimens. All the specimens are housed in the Department of Geology, Faculty of Science, Niigata University.

Stratigraphy

The Oguradani Formation, now redefined, corresponds with both the Oguradani and Ashidani Formations of Yamada (1966, 1967). It is widely distributed in the Ise district, overturned entirely with the dips of 30-80° S and the strike of E-W to NW-SE. This formation, consisting of Permian

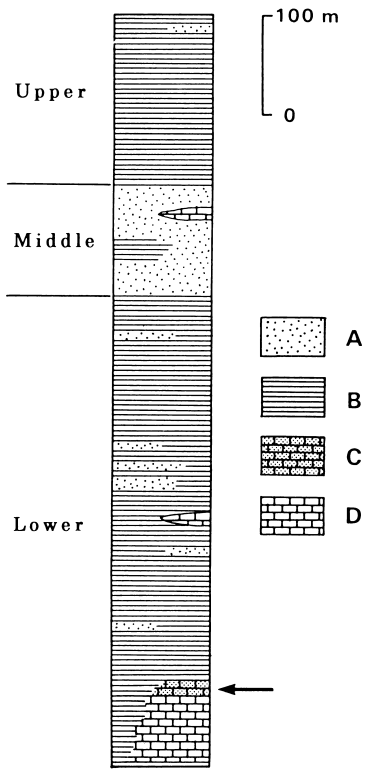

Fig. 2. Columnar section of the Oguradani Formation in the Ise district, showing the stratigraphical position of the fossil locality (arrow). A: Sandstone, B: Shale, C: Argillaceous impure limestone, D: Limestone.

shales, sandstones and limestones, overlies with probable conformity the Carboniferous Konogidani Formation, and contacts with faults the Upper Permian (?) Otani Formation and the Upper Jurassic-Lower Cretaceous Tetori Group. The Oguradani Formation is divided lithologically into three members, the lower shale-limestone member of 470 m thick, the middle sandstone member of 110 m thick, and the upper shale member of 170 m+ thick. The total thickness attains over 750 m. The brachiopod fossils described in this paper were collected from dark-grey argillaceous impure limestone, 15 m thick, situated at 70 m above the base of the formation (Fig. 2).

The Oguradani fauna

The brachiopods of Oguradani described here and the number of specimens are shown as follows:

Derbyia cf. *buchi* (d'Orbigny) 3
Meekella sp. 1
Transennatia gratiosa (Waagen) 5
Leptodus nobilis (Waagen) 9
Stenoscisma margaritovi (Tschernyschew) 7
Hustedia cf. *grandicosta* (Davidson) 1

Among these species, *Stenoscisma margaritovi* has been known from the lower Middle Permian (Bolorian-Kubergandian) of Japan, Eastern Russia, Northeast China and Inner Mongolia, namely, the lower Moribu Formation of the Moribu district, Hida Gaien Belt, Central Japan (Horikoshi *et al.*, 1987); the lower Kanokura Formation of the Southern Kitakami Mountains, Northeast Japan (Hayasaka, 1922a, 1966; Tazawa, 1976; Minato *et al.*, 1979); the Chandalaz Formation of South Primorye, Eastern Russia (Tschernyschew, 1888; Frederiks, 1924; Licharew and Kotljar, 1978; Koczyrkevics, 1979); the Miaoling Formation of Yanji, Jilin Province (Lee *et al.*, 1980) and the Tumenling Formation of Acheng, Heilongjiang Province, Northeast China (Lee *et al.*, 1980); and the Jisu (Zhesi) Formation of Jisu, Inner Mongolia, North China (Lee and Gu, 1976; Duan and Li, 1985).

Transennatia gratiosa has been described from the Middle and Upper Permian of Timor, Pakistan, Nepal, Cambodia, Vietnam, South China, North China, Northeast China, Eastern Russia and Japan. And the Oguradani specimens resemble the shells of *T. gratiosa* from the lower Moribu Formation of the Moribu district, Hida Gaien Belt, Central Japan (Tazawa, 1991); the lower Kanokura Formation of the Southern Kitakami Mountains, Northeast Japan (Hayasaka, 1960); the upper Vladivostok and Chandalaz Formations of South Primorye, Eastern Russia (Licharew and Kotljar, 1978); the Miaoling Formation of Yanji, Jilin Province, Northeast China (Lee *et al.*, 1980); and the Middle Permian of Jalaid Qi, Inner Mongolia, North China (Lee *et al.*, 1980).

Leptodus nobilis is a widely distributed species and has been known from the Middle and Upper Permian of Croatia, Serbia, Hungary, Western and Eastern Russia, Pakistan, India, Nepal, Cambodia, Laos, Timor, Northern Australia, China and Japan, including the lower Moribu Formation of the Hida Gaien Belt, Central Japan (Tazawa, 1987); the lower Kanokura Formation of the Southern Kitakami mountains, Northeast Japan (Yabe, 1900; Hayasaka, 1917, 1922a; Tazawa, 1976; Minato *et al.*, 1979); the upper Barabashu (Chandalaz) and Lyudyanza Formations of South Primorye, Eastern Russia (Licharew and Kotljar, 1978; Kotljar and Zakharov, 1989); the Tumenling Formation of Wuchang, Heilongjiang Province, Northeast China (Lee *et al.*, 1980); the Huanggangliang Formation of Hexigten Qi (Lee *et al.*, 1980), the Middle Permian of Horqin Youyi Qianqi (Lee *et al.*, 1980) and the Jisu and Yihewusu Formations of Jisu (Grabau, 1931; Lee and Gu, 1976; Duan and Li, 1985), Inner Mongolia, North China.

Moreover, *Derbyia* and *Stenoscisma* are the Bipolar-type of genera, and *Meekella, Transennatia* and *Leptodus* are typical Tethyan-type genera.

Summarized from the above, the Oguradani fauna is correlated with the faunas of the lower Moribu Formation of the Moribu district, Hida Gaien Belt, Central Japan; the lower Kanokura Formation of the Southern Kitakami Mountains, Northeast Japan; the Chandalaz Formation of South Primorye, Eastern Russia; and the Miaoling Formation of Yanji, Jilin Province, Northeast China. These regions are characterized by the mixed brachiopod faunas of the Boreal-, Tethyan- and Bipolar-type genera, and belong to the Southern Subzone of the Inner Mongolian-Japanese Transition Zone of Tazawa (1991) in the Middle Permian biogeography.

Description of Species

Order Strophomenida Öpik, 1934
Suborder Orthotetidina Waagen, 1884
Superfamily Derbyioidea Stehli, 1954
Family Derbyidae Stehli, 1954
Genus *Derbyia* Waagen, 1884

Derbyia cf. *buchi* (d'Orbigny, 1842)
Pl. 1, figs. 1-2.

Compare.–
Orthis buchi d'Orbigny, 1842, p. 49.
Derbyia buchi (d'Orbigny): Kozlowski, 1914, p. 57, pl. 8, figs. 1-6; King, 1930, p. 58, pl. 8, figs. 4-6; Chronic, 1953, p. 57, pl. 12, figs. 19-21; Branisa, 1965, pl. 59, figs. 1-4.

Material.–Three specimens: (1) internal mould of a pedicle valve, NU-B129; (2) external and internal moulds of two brachial valves, NU-B130, 131.

Description.–Shell of small size for genus, subrectangular in outline, with hinge line slightly shorter than greatest width of shell, the latter occurring at midvalve; length about 24 mm, width about 23 mm in the pedicle valve specimen (NU-B129); length 29 mm, width 29 mm in the better preserved brachial valve specimen (NU-B130).

Pedicle valve slightly convex in lateral and anterior profiles. Brachial valve also slightly convex in both profiles. External surface of brachial valve costellate; costellae narrowly spaced and evenly developed, numbering 10-11 in 5 mm at midvalve. Concentric rugae occurring near anterior margins.

Internally pedicle valve having a strong median septum extending near midvalve. Brachial valve having a long, bifid cardinal process and a pair of short, strong and divergent crural plates.

Remarks.–These specimens resemble the shells of *Derbyia buchi* (d'Orbigny, 1842), described or figured from the Lower Permian Copacabana Group of the Peruvian-Bolivian Basin, South America (d'Orbigny, 1842; Kozlowski, 1914; Chronic, 1953; Branisa, 1965) and the Wolfcampian of West Texas (King, 1930), in size, shape and external ornament.

Derbyia crassa (Meek and Hayden) from the Pennsylvanian of the United States is also small, subrectangular *Derbyia*, but the American species is clearly distinguished from the present species by its costellae, regularly alternating of stronger and weaker ones (see Girty, 1915, pl. 7, figs.1-1c; Dunbar and Condra, 1932, pl. 3, figs. 1-12).

Derbyia nipponica Nakamura (1972, p. 399, pl. 7, figs. 1, 4-9) from the lower Kanokura Formation of the Southern Kitakami Mountains, Northeast Japan differs from *D. buchi* in its much larger size.

Family Meekellidae Stehli, 1954

Genus *Meekella* White and St. John, 1867

Meekella sp.
Pl. 1, figs. 3a-d.

Material.–One specimen, external and internal moulds of a brachial valve, NU-B132.

Remarks.–The brachial valve is transversely oval in outline, length 23 mm, width about 27 mm, slightly convex and ornamented by 10 or more broad costae with numerous fine costellae, and has a pair of long socket plates diverging anteirorly. This specimen is safely assigned to the genus *Meekella* by its shape, external ornament and internal structure of the brachial valve.

The Oguradani specimen superficially resembles the shells of *Meekella striatocostata* (Cox), described by Dunbar and Condra (1932, p. 125, pl. 16, figs. 1-10; pl. 17, figs. 3a-c) from the Pennsylvanian of Nebraska and *Meekella* cf. *striatocostata* (Cox), described by Nakamura (1972, p. 385, pl. 5, figs. 1a, b) from the lower Kanokura Formation of the Southern Kitakami Mountains, Northeast Japan. But accurate comparison is difficult for the poorly preserved specimens.

Order Productida Waagen, 1883
Suborder Productidina Waagen, 1883
Superfamily Productoidea Gray, 1840
Family Productellidae Schuchert in Schuchert and Levene, 1929
Subfamily Marginiferinae Stehli, 1954
Genus *Transennatia* Waterhouse, 1975

Transennatia gratiosa (Waagen, 1884)
Pl. 1, figs. 4-8.

Productus gratiosus Waagen, 1884, p. 691, pl. 72, figs. 3-7; Diener, 1897, p. 23, pl. 3, figs. 3-7; Rothpletz, 1892, p. 76, pl. 10, figs. 15-15c; Mansuy, 1913, p. 115, pl. 13, figs. 1a, b; Broili, 1916, p. 12, pl. 116, figs. 4, 5, 7-13; Colani, 1919, p. 10, pl. 1, figs. 2a-c; Chao, 1927, p. 44, pl. 4, figs. 6-10; Chi-Thuan, 1962, p. 491, pl. 2, figs. 5-7.

Productus (Dictyoclostus) gratiosus Waagen: Huang, 1933, p. 88, pl. 11, figs. 14a, b; Hayasaka, 1960, p. 49, pl. 1, fig. 8.

Marginifera gratiosa (Waagen): Reed, 1944, p. 98, pl.19, figs. 6-7.

Dictyoclostus gratiosus (Waagen): Zhang and Ching, 1961, p. 411, pl. 4, figs. 12-18.

Gratiosina gratiosa (Waagen): Grant, 1976, pl. 33, figs. 19-26; Licharew and Kotljar, 1978, pl.12, figs. 5, 6; pl. 20, figs. 1a, b; Minato *et al.*, 1979, pl. 61, figs. 11-13.

Asioproductus gratiosus (Waagen): Yang *et al.*, 1977, p. 350, pl.140, figs. 5a-c; Feng and Jiang, 1978, p. 254, pl. 90, figs. 1-2; Tong, 1978, p. 228, pl. 80, figs. 7a, b; Lee *et al.*, 1980, p. 373, pl. 164, figs. 14a-c; pl. 166, figs. 5-6.

Asioproductus bellus Chan (Zhan), 1979, p. 85, pl. 6, figs. 7-13; pl. 9, figs. 8-10; text-fig. 18.

Gratiosina sp. Minato *et al.*, 1979, pl. 61, fig. 14; Tazawa, 1991, p. 215.

Transennatia gratiosus (Waagen): Liu *et al.*, 1982, p. 185, pl. 132, figs. 9a-d; Ding and Qi, 1983, p. 280, pl. 95, figs. 14a, b.

Material.–Five specimens: (1) external and internal moulds of a pedicle valve, NU-B133; (2) internal mould of a pedicle valve, NU-B134; (3) external and internal moulds of two brachial valves, NU-B135, 136; (4) external mould of a brachial valve, NU-B137.

Description.–Shell of small size for genus, subquadrate in outline, length and width approximately equal; length 13 mm, width 12 mm in the smaller but well preserved pedicle valve specimen (NU-B133), length 9 mm, width 16 mm in the best preserved brachial valve specimen (NU-B135).

Pedicle valve strongly convex in lateral profile, slightly geniculated at anterior margin of venter, and followed by a long trail. Umbo small, slightly incurved. Ears small but distinct and pointed, clearly demarcated from visceral part. Sulcus narrow and deep, originating a little below umbo, and extending to anterior margin of valve. Brachial valve nearly flat on visceral disc, slightly geniculated at anterior margin of visceral disc, and followed by a short trail. Fold narrow and low, but widely developed in one specimen (NU-B137). External surface of pedicle valve reticulate on venter, and costate on trail. Costae converging into sulcus anteriorly, numbering 11-13 in 5 mm at midvalve. External ornament of brachial valve similar to the opposite valve.

Internal structure of both valves are not well preserved in the present material.

Remarks.–These specimens are referred to *Transennatia gratiosa* (Waagen, 1884), originally described by Waagen (1884) from the Wargal and Chhidru Formations of the Salt Range. The shell size of the Oguradani specimens is smaller than that of the Salt Range specimens, and comparable with the relatively small shells of *T. gratiosa* from the Middle Permian of the Hida Mountains, Central Japan (Tazawa, 1991), the Southern Kitakami Mountains, Northeast Japan (Hayasaka, 1960), South Primorye, Eastern Russia (Licharew and Kotljar, 1978) and the Heilongjiang and Jilin Provinces, Northeast China (Lee *et al.*, 1980).

Transennatia insculpta (Grant, 1976, p. 135, pl. 32, figs. 1-37; pl. 33, figs. 1-16) from the Rat Buri Limestone of Ko Muk, southern Thailand is close in general appearance, but the Thai species is distinguished from the present species by its wider shell and more prominent ears.

Transennatia huananensis (Zhan, 1979, p. 86, pl. 6, figs. 14-16) from the Longtan Formation of Guangdong Province, South China is also small in size, but differs from *T. gratiosa* in having larger number of fine costae on the pedicle valve.

Suborder Strophalosiidina Waagen, 1883
Superfamily Lyttonioidea Waagen, 1883
Family Lyttoniidae Waagen, 1883
Subfamily Lyttoniinae Waagen, 1883
Genus *Leptodus* Kayser, 1883

Leptodus nobilis (Waagen, 1883)
Pl. 2, figs. 7-12.

Lyttonia nobilis Waagen, 1883, p. 398, pl.29, figs. 1-3; pl. 30, figs. 1, 2, 5, 6, 8, 10, 11; Diener, 1897, p. 37, pl. 1, figs. 5-7; Noetling, 1904, p. 112, text-figs. 4-7; Noetling, 1905, p. 140, pl. 17, figs. 1,2; pl. 18, figs. 1-11; text-fig. 2; Mansuy, 1913, p. 123, pl. 13, fig. 10; Mansuy, 1914, p. 32, pl. 6, figs. 7a-d; pl. 7, figs. 1a-e; Diener, 1915, p. 99, pl. 10, fig. 15; Grabau, 1931, pars, p. 285, pl. 28, figs. 4, 5 only; Huang, 1932, p. 89, pl. 7, figs. 9, 10; pl. 8, figs. 8, 9; pl. 9, figs. 1-8; text-figs. 8-11; Simic, 1933, p. 49, pl. 4, fig. 1.

Lyttonia tenuis Waagen, 1883, p. 401, pl. 30, figs. 3, 4, 7, 9.

Lyttonia sp. Yabe, 1900, p. 2, text-figs. 1, 2.

Lyttonia richthofeni (Kayser): Frech, 1911, pars, p. 135, pl. 20, figs. 2a, b only; Mashiko, 1934, p. 182, text-fig.

Lyttonia cf. *tenuis* Waagen: Mansuy, 1912, p. 19, pl. 4, fig. 4; pl. 5, figs. 1a-c; Huang, 1936, p. 493, pl. 1, fig. 6.

Lyttonia richthofeni Kayser: Hayasaka, 1917, p. 43, pl. 18, figs. 1-8; Hayasaka, 1922a, p.62, pl. 11, figs. 1-6; Hayasaka, 1922b, p. 103, pl. 4, figs. 12, 13.

Lyttonia (Leptodus) richthofeni Kayser: Hamlet, 1928, p. 31, pl. 6, figs. 1-4.

Lyttonia cf. *richthofeni* (Kayser): Huang, 1932, p. 87, pl. 8, figs. 4a, b.

Lyttonia richthofeni Kayser forma *nobilis* Waagen: Licharew, 1932, p. 69, 96, pl. 2, figs. 13, 14; pl. 5, figs. 1-4, 6; text-fig. 3.

Leptodus nobilis Waagen: Wanner and Sieverts, 1935, p. 249, pl. 9, figs. 27, 28; text-figs. 16-18; Cooper and Grant, 1974, pl. 191, figs. 8, 9.

Lyttonia cf. *nobilis* Waagen: Huang, 1936, p. 493, pl. 1, fig. 5.

Leptodus cf. *nobilis* (Waagen): Thomas, 1957, p. 177, pl. 20, figs. 1-6.

Leptodus nobilis (Waagen): Termier and Termier, 1960, p. 241, text-pl. 3, figs. 1-10; Chi-Thuan, 1961, p. 274, pl. 1, figs. 1a, b; Schréter, 1963, pl. 3, figs. 5-8; Sarytcheva, 1964, p. 65, pl. 7, figs. 5-8; text-fig. 1; Ruzhentsev and Sarytcheva, 1965, pl. 39, figs. 6-8; Grant, 1976, pl. 43, figs. 18, 19; Lee and Gu, 1976, p. 267, pl. 162, figs. 1, 2; Tazawa, 1976, pl. 2, fig. 8; Yang *et al.*, 1977, p. 371, pl. 147, fig. 5; Feng and Jiang, 1978, p. 269, pl. 100, fig. 2; Licharew and Kotljar, 1978, pl. 14, figs. 13-15; Jin *et al.*, 1979, p. 82, pl. 23, fig. 15; Minato *et al.*, 1979, pl. 66, figs. 1,4, 5; Zhan, 1979, p. 93, pl. 9, fig. 12; Lee *et al.*, 1980, p.389, pl. 172, figs. 15, 16; Wang *et al.*, 1982, p. 229, pl. 95, fig. 20; Zhan and Wu, 1982, pl. 4, fig. 4; Zhang *et al.*, 1983, p. 297, pl. 102, figs. 7, 8; Liao and Meng, 1986, p. 81, pl.2, figs. 24, 25; Sremac, 1986, p. 30, pl. 10, figs. 1-2; Tazawa, 1987, text-fig. 1.11; Kotljar in Kotljar and Zakharov, 1989, pl.20, fig. 6; pl. 23, fig, 12; Liang, 1990, p. 225, pl. 40, figs. 1, 5.

Leptodus richthofeni Kayser: Shimizu, 1961, pl. 18, figs. 14, 15; Sarytcheva, 1964, p. 65, pl.7, figs. 2-4; Yang *et al.*, 1977, p. 372, pl. 147, fig. 10; Duan and Li, 1985, p. 119, pl. 35, figs. 17-19.

Leptodus ivanovi Frederiks: Minato *et al.*, 1979, pl. 66, fig. 3.

Leptodus sp. Minato *et al.*, 1979, pl. 66, fig. 2; Tazawa, 1987, text-fig. 1.10.

Leptodus tenuis (Waagen): Wang *et al.*, 1982, p. 229, pl. 86, fig. 14; pl. 88, fig. 6; pl. 100, fig. 7; Duan and Li, 1985, p. 119, pl. 35, figs. 14-16; Liang, 1990, p. 226, pl. 40, fig. 9; Zhu, 1990, p. 79, pl. 18, figs. 19-21.

Gubleria sp. Zhu, 1990, p. 80, pl. 16, fig. 24.

Material.–Nine specimens: (1) external and internal moulds of two pedicle valves, NU-B138, 139; (2) internal moulds of seven pedicle valves, NU-B140-146.

Description.–Shell of medium size for genus, elongate subtrigonal to scoop-shaped in outline, with greatest width near anterior margin; length 56 mm, width 38 mm in the largest specimen (NU-B138); length ca. 40 mm, width 38 mm in the average-sized specimen (NU-B139).

Pedicle valve almost flat to slightly convex in both lateral and anterior profiles. Pedicle valve interior with regularly and symmetrically arranged lateral septa on both sides of median septum. Median septum highly developed. Lateral septa broad, solid, and straight to slightly arched toward front, numbering 14-15 on each side of median septum. Internal spaces 1.5-2.0 mm in width.

Remarks.–These specimens are referred to *Leptodus nobilis* (Waagen, 1883), originally described by Waagen (1883) from the Wargal and Chhidru Formations of the Salt Range in view of their shell outline and the feature of the lateral septa, although the Oguradani specimens are smaller than the Pakistan shells. *Leptodus nobilis* has been known from the Middle to Upper Permian of Croatia, Serbia, Hungary, Western Russia (Caucasus Mountains), Pakistan (Salt Range and Khisor Range), India (Kashmir), Nepal (Kumaon Himalayas), Cambodia, Laos, Timor, Northern Australia (Port Keats), Northwest China (Tibet, Qinghai), South China (Yunnan, Guangxi, Guizhou, Sichuan, Hubei, Hunan, Guangdong, Jiangxi, Fujian, Zhejiang and Anhui Provinces), North China (Inner Mongolia), Northeast China (Jilin and Heilongjiang Provinces), Eastern Russia (South Primorye) and Japan (Southern Kitakami Mountains, Northeast Japan; Hida Mountains, Central Japan; Takauchi in Kyoto Prefecture, Southwest Japan).

Leptodus richthofeni Kayser, 1883, from the Permian of Loping, Jiangxi Province, South China (Kayser, 1883, p. 161, pl. 21, figs. 9-11; Cooper and Grant, 1974, p. 411, pl. 191, figs. 11-15) is distinguished from *L. nobilis* by its strongly convex pedicle valve, sharp lateral septa and wider interseptal spaces.

Order Rhynchonellida Kühn, 1949
Superfamily Stenoscismatoidea Oehlert, 1887
Family Stenoscismatidae Oehlert, 1887
Subfamily Stenoscismatinae Oehlert, 1887
Genus *Stenoscisma* Conrad, 1839

Stenoscisma margaritovi (Tschernyschew, 1888)
Pl. 2, figs. 1-5.

Camarophoria margaritovi Tschernyschew, 1888, p. 355, figs. 1-3; Frederiks, 1924, p. 48, pl. 1, figs. 32-42, text-fig. 4.

Camarophoria humbletonensis Howse: Hayasaka, 1922a, p. 62, pl. 9, figs. 10-12; pl. 10, fig. 9; Hayasaka, 1966, p. 1226, text-figs. 6-8.

Stenoscisma gigantea (Diener): Lee and Gu, 1976, p. 272, pl. 176, fig. 3; pl. 177, fig. 18.

Stenoscisma humbletonensis (Howse): Tazawa, 1976, pl. 2, figs. 9, 10; Minato *et al.*, 1979, pl. 66, figs. 6-8.

Stenoscisma margaritovi (Tschernyschew): Licharew and Kotljar, 1978, pl. 17, figs. 7a, b; Koczyrkevicz, 1979, p. 50, pl. 11, figs. 5, 6; Duan and Li, 1985, p. 120, pl. 43, figs. 5-8.

Stenoscisma purdoni (Davidson): Lee *et al.*, 1980, p. 395, pl. 173, figs. 4, 5, 7.

Stenoscisma gigantea (Diener): Lee *et al.*, 1980, p. 395, pl. 173, figs. 6, 8.

Stenoscisma gigantea elongatum Lee, Gu and Su, 1980, p. 395, pl. 173, figs. 1, 2.

Stenoscisma sp. Horikoshi *et al.*, 1987, p. 142.

Material.–Seven specimens: (1) external mould of a pedicle valve with internal mould of a conjoined valve, NU-B147; (2) external and internal moulds of two pedicle valves, NU-B148, 149; (3) external moulds of two pedicle valves, NU-B150, 151; (4) internal mould of a pedicle valve, NU-B152; (5) external and internal moulds of a brachial valve, NU-B153.

Description.–Shell of large size for genus, elongate subtrigonal in outline, with greatest width at two thirds length of shell; length 33 mm, width 29 mm in the best preserved pedicle valve specimen (NU-B148).

Pedicle valve gently convex in lateral profile, most convex at umbonal region and slightly convex to flat on anterior half of valve. Umbo small. Sulcus shallow and wide. External surface of pedicle valve ornamented by strong, rounded costae, numbering 9 on sulcus and 6-7 on each flanks. Brachial valve gently convex in both lateral and anterior profiles, with a low fold. Surface ornament same as pedicle valve.

Internal structure of both valves are obscure in the present material.

Remarks.–These specimens can be referred to *Stenoscisma margaritovi* (Tschernyschew, 1888), originally described from the Permian in the Vladivostok region, South Primorye, by their elongate and narrow outline, shallow ventral sulcus and low dorsal fold, and rather numerous rounded costae on the both valves. *S. margaritovi* is known from the Middle Permian of Inner Mongolia (Jisu), Northeast China (Heilongjiang and Jilin), Eastern Russia (South Primorye) and Japan (Southern Kitakami Mountains).

The shells described or figured as *Stenoscisma humbletonensis* (Howse, 1848), from the lower Kanokura Formation of the Southern Kitakami Mountains, Northeast Japan (Hayasaka, 1922a, 1966; Tazawa, 1976; Minato *et al.*, 1979), are referred to *S. margaritovi* on the basis of their shallow ventral sulcus, low dorsal fold, and relatively large number of costae on the both valves.

The elongate, large *Stenoscisma*, described by Lee and Gu (1976) and Lee *et al.* (1980) as *Stenoscisma purdoni* (Davidson, 1862), *Stenoscisma gigantea* (Diener, 1897) and *Stenoscisma elongatum* Lee, Gu and Su, 1980 from the Middle Permian of Northeast China and Inner Mongolia may be conspecific with the present species.

Order Retziida Waterhouse, 1981

Suborder Retziidina Boucot, Johnson and Staton, 1964

Superfamily Retzioidea Waagen, 1883

Family Retziidae Waagen, 1883

Genus *Hustedia* Hall and Clarke, 1893

Hustedia cf. *grandicosta* (Davidson, 1862)
Pl. 2, figs. 6a-c.

Compare.–
Retzia radialis var. *grandicosta* Davidson, 1862, p. 28, pl. 1, figs. 5a, b.
Eumetria grandicosta (Davidson): Waagen, 1883, p. 491, pl. 44, figs. 6-12.
Retzia (Hustedia) grandicosta Davidson: Diener, 1903, p. 24, pl. 2, figs. 8a-d, 10.
Retzia (Hustedia) radialis var. *grandicosta* Davidson: Broili, 1916, p. 51, pl. 124, figs. 14-22; pl. 125, figs. 1-3.
Hustedia grandicosta (Davidson): Grabau, 1934, p. 105, pl. 7, figs. 5a-c; Shimizu, 1961, p.328, pl. 16, figs. 39-42; Lee and Gu, 1976, p. 275, pl. 160, fig. 17; Koizumi, 1979, pl. 1, fig. 7.
Hustedia radialis var. *grandicosta* Davidson: Chi-Thuan, 1961, p. 300, pl. 4, figs. 1-2.

Material.–One specimen, external mould of a pedicle valve with internal mould of a conjoined valve, NU-B154.

Remarks.–The single specimen from Oguradani is strongly distorted and the external mould of the pedicle valve is fragmentary. However, this specimen is safely assigned to the genus *Hustedia* by its small, elongately oval shell (length ca. 9 mm, width ca. 8 mm), ornamented by strong costae on the both valves (12 or 13 costae on the pedicle valve). The Oguradani species most resembles *Hustedia grandicosta* (Davidson, 1862) in its elongate outline, narrow umbo and rather numerous costae on the pedicle valve. *H. grandicosta* has been known from the Lower Permian of Pakistan (Salt Range), Nepal (Kumaon Himalayas), Timor, Cambodia, South China (Guizhou), North China (Inner Mongolia) and Japan (Abukuma Mountains, Northeast Japan; Hida Mountains, Central Japan; and Kawahigashi in Kyoto Prefecture, Southwest Japan).

Hustedia lata (Grabau, 1931, p. 124, pl.5, figs. 5a-e), from the Middle Permian Jisu Honguer Limestone (Yihewusu Formation of Ding *et al.*, 1985) in the Jisu (Zhesi) district, Inner Mongolia, also has numerous costae on the pedicle valve, but it differs from the present species by its more transverse shell with larger apical angles.

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Explanation of Plates

(Natural size unless otherwise indicated)

Plate 1

Figs. 1, 2. *Derbyia* cf. *buchi* (d'Orbigny)

1. Internal mould of pedicle valve, NU-B129, 2a-d. External mould of brachial valve, latex cast, counterpart internal mould and latex cast, NU-B130.

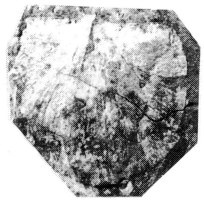
Figs. 3a-d. *Meekella* sp.

3a-d. External mould of brachial valve, latex cast, counterpart internal mould and latex cast, NU-B132.

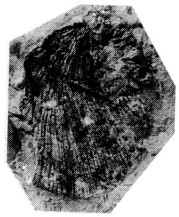
Figs. 4-8. *Transennatia gratiosa* (Waagen)

4a-d. External mould of brachial valve, latex cast and counterpart internal mould, NU-B136, 4b-d ×2, 5a, b. Internal mould of pedicle valve, NU-B134, 5b ×2, 6a-c. External mould of brachial valve and counterpart internal mould, NU-B135, 6b, c ×2, 7a-c. External mould of pedicle valve and counterpart internal mould, NU-B133, 7b, c ×2, 8a, b. Extenal mould of brachial valve, NU-B137, 8b ×2.

Plate 1

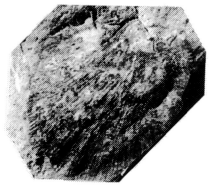


1

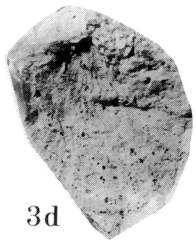


3a

3b



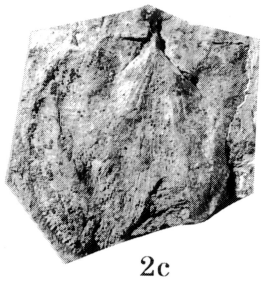
3c



3d

2a

2b



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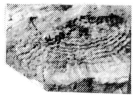
2d



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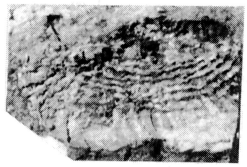

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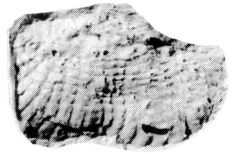

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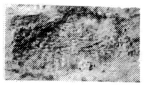
5a

5b



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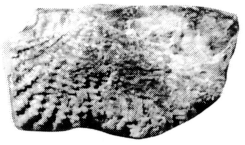

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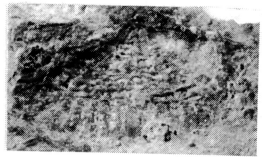

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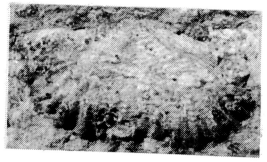

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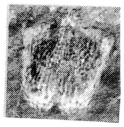

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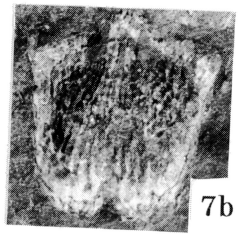

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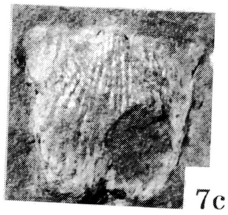

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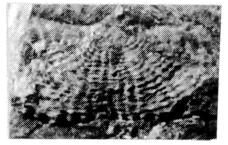

8b

Plate 2

Figs. 1-5. *Stenoscisma margaritovi* (Tschernyschew)

1a, b. External mould of pedicle valve and latex cast, NU-B148, 2a-d. External mould of pedicle valve, latex cast, counterpart internal mould and internal mould of opposite brachial valve, NU-B147, 3. Latex cast of brachial valve, NU-B153, 4. Latex cast of pedicle valve, NU-B149, 5. Latex cast of pedicle valve, NU-B150.

Figs. 6a-c. *Hustedia* cf. *grandicosta* (Davidson)

6a-c.Internal moulds of pedicle valve and opposite brachial valve, NU-B154, 6b, c ×2.

Figs. 7-12. *Leptodus nobilis* (Waagen)

7. Internal mould of pedicle valve, NU-B143, 8a, b. Internal mould of pedicle valve and latex cast, NU-B139, 9. Internal mould of pedicle valve, NU-B142, 10a, b. Internal mould of pedicle valve and latex cast, NU-B141, 11a, b. Internal mould of pedicle valve and latex cast, NU-B138, 12. Internal mould of pedicle valve, NU-B140.

Plate 2